indicate the column index for the non-zero entry. A method for generating these arrays and matrices is then automatically generated based on the formulation of the present invention.

Please amend the paragraph on page 5, line 5, as follows:

The basic steps for populating [there] these matrices are as follows:

In the Claims:

Please amend the claims as follows. A clean copy of the amended claims is attached.

Claim 11 (Amended). The method of claim 4, wherein step (f) is performed by [an] a linear programming/integer programming (LP/IP) solver.

REMARKS

Submitted herewith in a separate letter is proposed drawing corrections to Figures 5, 6, 7, 9, and 10. Specifically, each of these figures is to be corrected by adding missing arrows to the flow diagrams and, where needed, the legends –YES– or –NO– to outputs of decision blocks. Upon approval by the Examiner, new sheets of formal drawings, incorporating the proposed drawing corrections, will be submitted.

Claims 1 to 11 remain in the application.

In response to the Examiner's objection to claim 11, claim 11 has been amended as required by the Examiner.

The claimed invention is directed to an improved computer implemented method for selecting bids in a reverse combinatorial auction. The method

according to the invention automatically selects the optimal bid when commodities are offered in bundles by automatically generating an algorithm which may be implemented on a computer for solving the cost-minimization problem. The auction is run as a procurement auction, where the buyer (e.g., a manufacturer) wishes to purchase different items of varying quantities for the cheapest overall price. The total quantity of each item is referred to as a lot and is treated as an indivisible unit of some weight. Suppliers can bid on combinations of items; however, a bid on any item has to be for the entire lot for that item. The present invention identifies the optimal solution to the so-called winner determination problem for a single-unit reverse combinatorial auction by selecting a winning set of bids such that each item is included in at least one winning bid. As a result, the total cost of procurement is minimized. This problem is a set covering problem, which is known to be NP-hard. NP-hard problems are problems that are difficult to solve and the amount of effort (in terms of the time required on a computer) increases exponentially as the size of the problem (such as number of bids) increases. For example, if the number of bids goes from 100 to 200, then the time required to solve the problem might go from 10 seconds to 100 seconds (not 20 seconds).

The claimed invention provides an algorithm for identifying a cost-minimizing bid set in a reverse combinatorial auction subject to various business rules for all-or-nothing bundled bids, and second by providing a method for automatically generating this algorithm in a form that can be used with commercial Linear Programming/Integer Programming (LP/IP) solvers. In accordance with the invention, a computer-implemented formulation is generated by populating a set of matrices. Since the matrix is generally sparse, it is represented in a sparse form by providing only the non-zero terms. This is done by specifying a large array of non-zeros indexed by an integer array that indexes the row number for each non-zero entry. Additionally, two column vectors are specified that indicate the column index for the non-zero entry. These arrays are

automatically generated, and the matrices are then automatically generated based on the formulation of the present invention.

The basic steps for populating these matrices are as follows:

1. Given the number of suppliers, N, and the bids M_i for each supplier, the number of minimum (S_{min}) and maximum (S_{max}) winning suppliers.

2. Identify the number of decision variables as $\sum_{i \in N} M_i + N$.

3. Identify the total non-zero entries in the matrix A based an the number of items in each bid and the total number of suppliers.

4. Identify the number of rows in the matrix based on the total number of items and suppliers.

5. For each bid, introduce a column and populate the matrix A with non-zero elements with appropriate row and column indices.

6. For each bid, populate the cost vector c with the bid price.

7. Call a commercial solver with these matrices as input and invoke the solver.

8. Read the winning bids found by solver.

Claim 1 was rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 6,272,473 to Sandholm in view of U.S. Patent No. 5,974,403 to Takriti et al. This rejection is respectfully traversed for the reason that the combination of Sandholm and Takriti et al. fails to suggest the claimed invention.

Sandholm discloses a computer implemented method and data structures for solution of problems of the class equivalent to optimal allocation determination in a combinatorial auction. Bids are stored in a binary tree which is searched in conjunction with a stopmask data structure which allows, in effect, parts of the binary tree to be instantly pruned during search and in place.

The Examiner cites col. 1, lines 46 to 65, of Sandholm as disclosing "a method for identifying a cost minimizing bid set for reverse combinatorial

auctions". The cited passage first describes combinatorial auctions, where the seller offers various combinations to prospective bidders, and then, at lines 62 to 65, mentions that a reverse auction, where the buyers are the auctioneers, may be had in the context of a construction contract offered to be bid upon by construction contractors. However, the Examiner attributes more to the cited passage than appears to be justified. Specifically, the Examiner states that this passage describes a method of identifying a cost minimizing bid set, but that does not appear to be the case. The cited passage is set out in the "Background" section of the Sandholm patent, and Applicants also acknowledge that reverse combinatorial auctions are known (see pages 1 to 3 of the specification). However, Applicants also describe shortcomings in known methods.

The focus of the claimed invention is the incorporation of business rules for bid evaluation in the context of reverse combinatorial auctions. Incorporating such rules into a basic optimization model such as the set covering model is inherently difficult and changes the nature of the mathematical programming/ optimization model substantially. The method of Sandholm does not teach a mathematical programming based where a linear programming relaxation is used to guide the search. As a result, introducing the business rules as constraints renders Sandholm's methods unusable.

Although there are seven steps recited in claim 1, the Examiner has accounted for only three in his treatment of the Sandholm patent. The Examiner states that "Sandholm fails to teach modeling demand constraints for each item using the bid variables", and further that "Sandholm fails to disclose modeling minimum and maximum numbers of suppliers based on the counting variables." For these two steps, the Examiner relies on the patent to Takriti et al.

Takriti et al. discloses a computer implemented tool for forecasting the spot price of electric power in a deregulated market and the amounts of power that may be traded. Using generating capacities of multiple utilities, price fluctuations, weather forecasts, and transmission variables, the computer implemented tool

makes these forecasts at different delivery points, providing the decision maker with probabilistic distributions for spot prices for trading.

The Examiner cites col. 3, line 29, to col. 4, line 11, and col. 9, lines 29 et seq., of Takriti et al. as teaching "a tool for forecasting the spot-market prices of electrical power and trading transactions at different delivery points using statistical modeling demand constraints to manage risk more effectively and determine electrical cost minimization", and concludes that since "Sandholm contemplates a reverse combinatorial auction where in minimized cost is desirable", it would have been obvious "to integrate the modeling of command constraints, as taught by Takriti to provide the bidders an alternative means to provide optimal allocation in combinatorial auction." It is not clear what the Examiner has in mind in this modification of Sandholm but it should be observed that (1) Takriti et al. are solving a totally different problem than that solved by Sandholm, to wit forecasting spot price of electric power, and (2) the claimed invention is to a process performed by the buyer, not the bidders. There appears to be no reasonable basis for the modification proposed by the Examiner and, in any case, the modification would not result in th claimed invention.

The method taught by Takriti et al. is not relevant to the claimed invention. The Takriti et al. method cannot be combined with a set covering model to generate a useful model bid evaluation – a fundamental reworking of the set covering model to incorporate business constraints is required. This is not obvious from the combination of Takriti et al. with Sandholm. Note that Takriti et al. at column 9, lines 49 et seq., provides a method for sampling the uncertainty in price distributions and does not allow for the introduction of constraints on the number of winning suppliers. Similarly, the introduction of timestamps is novel since it requires the solution of a multi-objective problem that requires goal programming for which neither Sandholm nor Takriti et al. can be adapted.

Claims 2 and 3 were rejected under 35 U.S.C. §103(a) as being unpatentable over the patents to Sandholm and Takriti et al. as applied to claim 1

further in view of U.S. Patent No. 6,415,270 to Rackson et al. This rejection is respectfully traversed for the reasons advanced above that the combination of Sandholm and Takriti et al. fails to suggest the claimed invention as recited in claim 1 and the addition of the patent to Rackson et al. fails to cure the lack of teaching of the basic combination.

The Examiner states that "Sandholm as modified by Takriti fails to teach the auction is an [sic] single round and/or the auction is a multiple round auction." The Examiner cites the Abstract of the Rackson et al. patent as disclosing both single and multiple round auctions.

Rackson et al. disclose a multi-auction service system and method for replicating an item to be auctioned at a plurality of remote auction services, where the multi-auction service detects bids at the plurality of remote auction services for the item in order to replicate the optimal bid at each of the remote auction services such that the optimal bid is afforded to a bidder or seller.

The method according to the claimed invention is unique in its ability to return solutions in real time and can be incorporated into an interative format. This is not taught by Rackson et al., which provides a method for managing bids at multiple remote auctions. This is different from the claimed invention which refers to a single auction but provides a method for real time bid evaluation for an iterative format multi-round format.

Claims 4 and 6 to 11 were rejected under 35 U.S.C. §103(a) as being unpatentable over the patent to Sandholm in view of U.S. Patent No. 6,321,132 to Dawande et al. and U.S. Patent No. 6,094,645 to Aggarwal et al. This rejection is respectfully traversed for the reason that the combination of Sandholm, Dawande et al. and Aggarwal et al. fails to suggest the claimed invention.

The Examiner states that "Sandholm fails to disclose creating a set-covering formulation from the bids", and cites the Dawande et al. patent as teaching "the use of set covering formulation approach as a solution for slab covering design", citing col. 6, lines 37 et seq. of Dawande et al.

Dawande et al. disclose a computer implemented method to design slabs (the manufacturing unit in the steel industry) for production from an order book. The method minimizes the number of slabs designed to fulfill an order book. All the products are manufactured based on orders instead of being based on a forecast of the expected demand. The goal is to minimize the number of slabs needed to be manufactured, which for a given order book is equivalent to maximizing the average size of the slab.

The Examiner further states that "Sandholm fails to disclose adding predetermined business rules as a constraint to the set-covering formulation", and cites Dawande et al. as teaching "a set of 'compatibility conditions' that are used in the set-covering formulation as constraints", but the Examiner fails to point out where this is taught by Dawande et al. or what its relevance is. Dawande et al. teach a method for modifying the set covering model to include a set of compatibility conditions that are related to packing multiple items into a set. These compatibility constraints are based on whether members of a set are compatible with each other. These conditions are completely different from the business rules introduced in the claimed invention which relate to the cardinality of the set and hence lead to a fundamentally different mathematical model. The method of Dawande et al. cannot be adopted in any straight forward manner to model the business as in the claimed invention. In addition, note that one of the inventors of the Dawande et al. patent, Dr. Ho Soo Lee, is an inventor in the present invention and can state with high confidence the non-obviousness of the two models. As noted above, the method taught by Sandholm is unusable for mathematical programming based optimization models and cannot be adapted to incorporate new constraints.

The Examiner also cites the patent to Aggarwal et al. as teaching "using business rules as constraints to set-covering formulation, automatically generating a computer-implemented representation of the set-covering formulation as constrained by the business rules", citing col. 4, lines 24 et seq. of Aggarwal et al.

Aggarwal et al. disclose a computer implemented method of online mining of inference rules in a large database comprising a preprocessing stage and an online rule generation stage. The method taught by Aggarwal et al. is inherently different than the one of the claimed invention which relates to identifying a cost minimizing bid set that satisfies a given set of business rules.

Claim 5 was rejected under 35 U.S.C. §103(a) as being unpatentable over the combination of the patents to Sandholm, Dawande et al. and Aggarwal et al., as applied to claim 4, further in view of the patent to Rackson et al. This rejection is respectfully traversed for the reasons advanced above that the combination of Sandholm, Dawande et al. and Aggarwal et al. fails to suggest the claimed invention as recited in claim 4 and the addition of the patent to Rackson et al. fails to cure the lack of teaching of the basic combination.

The Examiner is reminded of the basic considerations which apply to obviousness rejections as set out in MPEP 2141. Specifically, "When applying 35 U.S.C. 103, the following tenets of patent law must be adhered to:

"(A) The claimed invention must be considered as a whole;

"(B) The references must be considered as a whole and must suggest the desirability and thus the obviousness of making the combination;

"(C) The references must be viewed without the benefit of impermissible hindsight vision afforded by the claimed invention; and

"(D) Reasonable expectation of success is the standard with which obviousness is determined."

It is respectfully submitted that the Examiner has attempted to reconstruct the claimed invention by various combinations of diverse references. This reconstruction has been made without considering the claimed invention as a whole, without considering the several references as a whole, based on hindsight afforded by the claimed invention, and without due consideration of any reasonable expectation of success.

The references cited but not relied upon have been considered but are not believed to be relevant to the claimed invention. Specifically, the patent to Ye teaches a general method for solving resource allocation problems by introducing lifted cover inequalities in to the problem formulation. Such a method can be used for general commercial solver engines; however, Ye does not teach a method for generating mathematical formulation for incorporating the business rules into the problem formulation for bid evaluation. As a result, this method cannot be used to solve the mathematical formulation of the claimed invention.

The patent to Alaia et al. teaches a method for dynamically extending the closing time for auctions that are related to multiple lots. This method is related closely to closing rules of the auction and is not directly relevant to the claimed invention. Bid evaluation is conducted in each round (or after the auction closes in first price auctions) and is completely unrelated to closing rules of auctions.

In view of the foregoing, it is respectfully requested that the application be reconsidered, that claims 1 to 11 be allowed, and that the application be passed to issue.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary in a telephonic or personal interview.

A provisional petition is hereby made for any extension of time necessary for the continued pendency during the life of this application. Please charge any fees for such provisional petition and any deficiencies in fees and credit any overpayment of fees to Attorney's Deposit Account No. 50-2041.

Respectfully submitted,

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Clean Copy of Amended Paragraphs

Paragraph beginning on page 4, line 17, and continuing to page 5, line 4, now reads as follows:

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a1

In addition, since the matrix A is generally sparse we represent it in a sparse form by providing only the non-zero terms. We do this by specifying a large array of non-zeros indexed by an integer array that indexes the row number for each non-zero entry. Additionally, we specify two column vectors that indicate the column index for the non-zero entry. A method for generating these arrays and matrices is then automatically generated based on the formulation of the present invention.

Paragraph on page 5, line 5, now reads as follows:

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a2

The basic steps for populating these matrices are as follows:

Clean Copy of Amended Claim

93 11. The method of claim 4, wherein step (f) is performed by a linear programming/integer programming (LP/IP) solver.